Abstract - The underrepresentation of women in engineering is often explained by gender differences in interests or abilities, learning environments and learning styles, or the uncertainty of the job market. But young women in Norway have largely overcome many of the traditional gender differences, and the job market is favourable. However, female engineering students lack role models and networks. Many leave the studies, and later the profession. This is known as the problem of the ‘leaky pipeline’. At the Faculty of Engineering, Oslo University College, serious attempts are made to help the female students succeed in their studies. A women’s network group has been formed, the aim of which is to give female students an opportunity to form networks in the same way that men do. Building networks helps with retention among women and underrepresented minorities. A mentoring project has been initiated, so that all first year female students will have their own mentor from the autumn term 2006.

Index Terms – Engineering, leaky pipeline, mentoring, under-representation of women.

INTRODUCTION

The number of female students who enter and complete engineering studies is significantly lower than expected, when compared to the percentages of female students in higher education. This phenomenon has been given various explanations over the years, for instance the biological and social differences between women and men, even differences in the construction of the brain, also family responsibilities, the work load of a technological and scientific career, or differences in general interests and abilities. Some of these explanations are sound, other less so, some are based on prejudice, or on research that today has been discarded.

However, research does show how female students often feel that technical careers are not ‘helping’ careers in the same way as teaching and nursing, and that for instance a computer engineer’s work is impersonal and individual. In order to recruit and retain female students such stereotypes must be corrected and replaced with visions of engineers working together as a team to solve complex and rewarding technical projects [1]. Whatever the causes for women underrepresentation may be, it is a concern that engineering studies are becoming overall less popular, and female representation in engineering education is going steadily down in many parts of the western world. It is becoming increasingly more difficult to recruit women to technological studies. Today, young women yearn for careers in media, design and nursing. The job market in Norway is still surprisingly sex-segregated, even after years of gender mainstreaming in all fields of education and society. Young women regard themselves as emancipated, and gender differences are no issue to them, but the choice of education and career is still extremely traditional.

RECRUITING AND RETAINING WOMEN IN ENGINEERING

Paradoxically, the situation in Norway and many other countries is such that women with good grades in engineering will be certain to get jobs. There is today an acute demand for engineers, and female engineers are extremely underrepresented in industry. Women should therefore be encouraged to pursue careers in technology. The engineering professions are not only technical, today, most work is performed in project teams, and communication skills, a traditionally female skill, are necessary. However, recruiting young women to engineering studies is a difficult task, as young women today do not seem to be attracted to technological studies. Various colleges and universities in Norway have made several attempts at recruiting young women during the past years, especially in the field of computer science. Amongst these are campaigns pointing out the ‘soft’ aspects of engineering, and awarding special scholarships to women, which has resulted in protests from male students. However, although such attempts have led to small successes for a few years running, namely resulting in an increasing number of female engineering students in the computer science department, the numbers are again going down, and many students leave after the first year. This indicates that the main problem is not how to recruit female students, but to retain those that have entered the studies. It is important to focus on the number of female students, not on percentages, and to help the female students to succeed by recognising their needs in typical male environments. This does not mean giving women advantages over men, but creating environments for women so that they are encouraged to complete their studies, and enter the engineering profession after they graduate. Women create their own learning strategies and learn to cope socially, and these strategies should be recognized and supported by the college or university.
The aim of all efforts to recruit and retain women in engineering should be that in the future it would be perfectly normal for women to enter technology studies and embark on technological careers. It is therefore imperative to focus on other aspects than the strictly technological when recruiting women to technological studies. Communication skills are today essential, and in recruitment campaigns, this aspect should be stressed, along with the fact that engineering work is project teamwork. Many women have the notion that engineering work, especially computer science, is a one-person discipline, with little or no contact with other people. Mentoring programs can help to correct this prejudice, because the students will be introduced to the working profession during their studies. Therefore, mentoring programs should incorporate all students, male and female. However, this paper discusses mentoring women and building networks for women, based on the experience at Oslo University College.

**The Pipeline Problem**

‘The leaky pipeline’ is a term used by the European Commission to describe how women fall away from engineering studies and careers in engineering. The European Commission established a group of national representatives responsible for women and science issues in both European Union Member States and countries associated to the Framework Programme in November 1999. This group is commonly known as the ‘Helsinki Group on Women and Science’, and has created a forum for sharing and comparing experiences. The Commission's Progress Report of May 2001 includes an update on the work of the Helsinki Group. The Helsinki Group members produced national reports on the situation of women scientists in their respective countries. The survey shows evidence that gender-segregation is a feature of scientific careers in all the countries surveyed [3]. This is indeed a serious concern. It means that women on the whole do not take an active part in the technological and scientific development. This again means that women have less influence on society than men do, because controlling technology means having the power and an influence on decision-making.

Even though enough women are encouraged to study technology and to enter technological and scientific professions, the underrepresentation of women in these professions will not disappear, because the ‘pipeline’ (i.e. the professions) is leaky in several places, and many women drop out along the way. In the early stages of the pipeline, the number of women is quite low compared to the number of men, and it decreases dramatically towards the end of the pipeline. Therefore, only a few women come out at the far end to launch on technological careers [11].

There is a deep concern in the European Union (EU) about the issue of women and science, expressed in the following statement: “There is considerable wastage of women’s skills and knowledge as a result of the ‘leaky pipeline’, whereby women drop out of scientific careers in disproportionate numbers at every level.” [5] In the year 2000, the General Directorate of Research in EU commissioned a report on gender aspects of research policy in the EU. The summary concludes that “Women constitute half the undergraduate population. However, there is a continuous drop in the numbers of women at each level of the academic ladder and many highly trained women are lost to science. Institutions that employ scientists tend to be behind the times in addressing the life/work balance and need to modernise” [7]. Many teachers and researchers have also documented the problem of retaining women in engineering education and professional life, and recommend mentoring as an efficient remedy. For instance, Julie Sheridan-Eng, an engineer at Lucent Technologies and chair of the Institute for Electrical and Electronics Engineers (IEEE) Committee on Women in Engineering, suggests that “The real problem is not to attract, but to retain those women who have entered the pipeline. This means adequate mentoring once women have joined a workplace, face-to-face and electronic networking to reduce feelings of isolation, attentiveness to workplace issues, and no tolerance for non-professional workplace behaviour” [8].

In order to compensate for the underrepresentation of women in various fields like science, politics, leadership and education, many countries use gender mainstreaming as a tool for establishing gender equality. Gender mainstreaming is the systematic integration of gender equality into all policies and programmes, organisations and their cultures. It is supported by the European Commission in its Communication: ‘Women and science – Mobilising women to enrich European Research’ [13]. Nordic countries in particular have been using gender mainstreaming as an integrated approach to gender equality in all fields. Attending to the special needs of women in engineering education is therefore in accordance with the recommendations of the European Commission, and does not imply making the studies easier for female students, as some men tend to believe.

**The Education Situation**

According to the EU report referred to above, “attracting more young people into science poses challenges for education. The sexstereotyping of science and scientists needs to be tackled through the curriculum, through pedagogy and through the media. Various strategies to encourage women to enter and remain in science are recommended. These include role models, mentoring, networks, schemes for parents returning after career breaks, and encouragement to women to apply for fellowships and posts.” [5].

The report proposes that something should be done about the curriculum, and problems be tackled through pedagogy. The engineering curriculum is often traditional, created by men, and the working examples often relate to male perspectives. Female engineering students often find themselves in classes that are predominantly male, with few, if any, female professors. In the computer science field, fewer than 10% of the full professors are female. The declining numbers of women entering the computer science major is well documented and has been discussed in many articles, for instance in Tracy Camp’s ‘The Incredible Shrinking Pipeline’.
An example of an attempt to tackle the problem is found at Stanford University, where several strategies have been undertaken over the past ten years in an effort to increase recruitment and retention of women in computer science at the undergraduate level. The principal components of that effort are as follows:

- Focus effort on increasing the number of women enrolled in computer science, as opposed to the percentage.
- Redesign the introductory sequence to make it accessible to a much wider audience.
- Provide role models for undergraduate women at every level of the educational process, including those who are only one or two years more advanced in age and experience.
- Institute a program to engage undergraduates in faculty research [9].

**Barriers for Women**

Research shows that there are many barriers to women's success in careers. These include, but are not limited to, a lack of professional and educational support systems, and work-family conflicts [10]. Today, statistics released by the EU show European women do better in school than men, but get lower pay and fewer top jobs. Eighty percent of all women complete secondary education compared to seventy-five percent of men, and more than half of all university students are women. However, women earn fifteen percent less than men and hold only a third of management jobs [6]. Women also have smaller chances of becoming scientists than men do, and careers will be slower than that of male colleagues, including those who are only one or two years more advanced in age and experience.

**Female Students at Oslo University College**

The fact that it is not enough to recruit female students to engineering studies stresses the importance of encouraging them to complete their studies, and later to stay in the profession. It is somewhat surprising that technological fields like computer science, electrical engineering, and building engineering do not appeal to women. Women have succeeded in biology, chemistry, law, and medicine, they succeed in starting small businesses, therefore, there is no obvious reason why women should shy away from engineering. In addition, it is depressing to discover that no change is in sight, on the contrary, the numbers of female students at The Faculty of Engineering has been going steadily down over the past few years. Today, fewer than ever young women enter the engineering studies, and many leave during the first and second year. The total representation of women is currently 263 out of a total of 1141 students, thus amounting to 18 percent. The figures vary on the different programmes. The computer science department has 16 percent female students, but in the Chemistry department, the percentage is high, around 65. Chemistry has become a female field. On the other hand, the mechanical engineering department has only 8 percent female students. The school also has approximately 40 percent minority students, and many of these are women. As many female students drop out early in the studies, and along the way, so the figures are higher at the beginning of the school year. The figures for the next semester are not yet clear, one of the reasons is that it is difficult to define gender from the names of the new applicants, many of whom are minority students.

*Athena Unbound. The Advancement of Women in Science and Technology.* The authors reveal the hidden barriers and the unwritten rules in the academic world, and document the professional and personal effects this has on women. The authors try to answer the question "why are there so few women in science and technology?", and discuss how one can improve recruitment of women technologists and scientists in the future. The book is based on studies and in-depth interviews with graduate students and employees in several universities, and gives a broad overview of the gender issues surrounding science and technology [11].

Since women are underrepresented in science and technology, they often find themselves alone in an all-male environment, and may therefore become 'invisible'. Unfortunately, though men theoretically may wish to include women, the traditional gender roles are still so deeply rooted that women are often regarded as less important than men. A fresh example from Oslo University College is illustrated in the case of a paper written by four co-authors, where their names were supposed to appear in alphabetical order. However, the woman scientist’s name came last. When this was pointed out, it was rapidly explained as a mistake. This was certainly unintentional, but the fact that nobody had noticed the mistake until after the paper was published indicates that the woman’s contribution was regarded as less important than her male colleagues’. She had simply become invisible. It is also interesting to note that she herself did not protest.

**Focus effort on increasing the number of women enrolled in computer science, as opposed to the percentage.**
The women’s networking group - ETWW

Lately, the College has recognized that it is even more important is to help female students to complete their studies than to recruit them. Bearing in mind the EU report, which states, “Various strategies to encourage women to enter and remain in science are recommended. Role models, mentoring, networks” [5], two college staff members formed a women’s network group in the autumn of 2004. Women do not create networks in the same way that men do, but it has been documented that women who participate in networking groups do well and become more self-assured [5]. The goals of the group are to help female students form lasting networks by getting to know each other, to indulge in both social and professional activities, and arrange seminars, talks and various courses. The students are supposed to initiate and be in charge of the activities in the group, but during the starting phase, the two staff members act as support and mentors. The students do not believe that having a group leader is important, but rather a staff representative who can help develop the group and secure continuity from one year to the next, until the foundation is solid. It is a hope that the existence of the group may have an effect when trying to recruit women to engineering studies.

The group is open to all female students at the Faculty of Engineering, and at social gatherings, the number of participants has been between 20 and 30. The group has been given the English name ‘Engineering and Technology the Women’s Way,’ ETWW for short. One of the goals of ETWW is to be the start of a women’s professional network. With so few women in engineering, it is important to look to those who have succeeded, and not focus on the percentage that drops out. The women’s group is for those who have chosen to study technology and wish to succeed. The aim is for the group members to stay in touch with each other after graduating, by including other women, thus expanding the network. Male scientists and engineers often have informal mentors who guide them in the unwritten rules of the profession. This is one of the explanations why men reach higher work positions than women. Where their networks support men, women often stand alone.

A second year student, who comes from the USA, made an interesting observation. “For me, this group may help me to succeed. I have heard that getting a job in Norway often happens through networks, and being part of a network is essential in order to understand the culture and the unspoken rules of professional life.”

ETWW Activities

An ETWW kick-off meeting in was held in October 2004. It was an informal gathering, with a short talk by an invited guest, a female computer professional. Other activities have consisted of social gatherings, discussion groups, a computer course, and a seminar on job seeking. The seminar had around 15 participants, and consisted of rehearsing job-interview situations with role-play, writing CVs and practising writing job applications. The computer course was held by a PhD student, and had 12 participants. Most of the students, even the computer science students, had never seen the inside of a computer before, and they had many questions to ask. The students were very satisfied with the course, they helped each other and taught each other along the way. Several more courses of this kind are planned for the next term. Other planned activities are a course in communication, and a job-seeking seminar.

One of the students who joined the network group states “equality at work, especially in the field of technology, starts with equality in education.” Women tend to believe that their skills are inferior to those of the male students. Many young women who start computer science studies feel that they know very little about computers, they are afraid to ask question, and feel ‘stupid’. On the other hand, young women use technology actively and experience great pleasure doing so, and giving courses in the use of computer technology, is a way to give the women an opportunity to master the technology and thus feel surer of themselves.

MENTORING

The word ‘mentor’ comes from Greek mythology and was the name of the guide Odysseus chose for his son Telemachos. A mentoring project is a form of co-operation where an older, more experienced person acts as adviser to a less experienced person – a mentee. A mentor provides personal information about a career. The information and contact with the industry that a mentor can provide is very valuable.

A female mentor is a role model who has first hand information about the profession she has chosen. A female engineer can encourage young women to choose a non-traditional education and profession. She can also aid women to understand the hidden structures in industry, especially in heavily male dominated fields. A mentoring program for women engineering students will help women in their careers, build networks and encourage them to stay in the profession.

1. Who can become a mentor?

A mentor can be a postgraduate student, a female engineer with work experience, an experienced junior or senior college student. The roles of a mentor are to:

- Provide personal support and academic advice to female students
- Provide general guidance, support and effective strategies to educational and professional success
- Assist the mentee in career path counseling.
- Determine goals with mentee
- Actively participate in the mentor program activities each semester

2. Objectives of a mentoring program.

The mentor is not a professional adviser, but should encourage personal and professional development. The goals of the program are to create a basis for mutual exchange of
knowledge and experience between mentee and mentor, enhance understanding of women’s skills and competence in general, and encourage personal and professional development and heighten self-esteem. Several colleges and universities now have mentoring programs for their female engineering students. In the UK, The Athena Project was established in 1999 by the UK higher education funding councils, and Office of Science and Technology, Department of Trade and Industry. Its aims are the advancement and promotion of the careers of women in science, engineering and technology (SET) in higher education and research to achieve a significant increase in the number of women recruited to top posts. In achieving its aims, Athena has worked in partnership with universities, research councils and SET professional and learned societies [12]. In Sweden, The Royal Institute of Technology in Stockholm, Uppsala University, and Stockholm’s University have had success with their mentor programs for female students. Universities in England and in The USA use mentoring as a way to improve the gender balance in certain professions. In Norway, NTNU was the first university to have a mentoring program (1997). The University in Tromsø started a mentoring project in 1999, and the University in Oslo is planning a project. In Norway, the Confederation of Norwegian Enterprise (NHO), has had a mentoring program with the Norwegian Sports organization order to recruit women for leadership. NHO also collaborates with the University College of Buskerud, Norway (HIBU). The aim of this mentoring project is to improve the study- and work situation for the students, and give the local industry access to the students’ skills.

3. The mentoring project at Oslo University College

After the initial phase of defining the purpose of the network group, establishing activities and formulating goals, the next step has been to initiate a mentoring program for the female students. This work is in its planning stage, and a mentor program will be introduced at semester start in August 2006. The role of the mentor is to give advice and to inspire. One young building engineer, who works as a project manager at a building site, was very enthusiastic about the project. When asked to describe her work she said: “I talk to people. If I need technical knowledge, I ask somebody. Many people possess technical knowledge, but not everybody is able to communicate.” She also hopes that the mentoring project will be a help in her company’s attempt to recruit more female engineers.

Several female students in their third and final year are prepared to become mentors after they graduate. Mentors are also recruited from industry in the Oslo area. Female engineers in several large industrial companies have been invited to join the program. By coming in touch with women who work as engineers, the students will learn what it takes to become successful in engineering. They will receive information about the tasks of an engineer, the barriers other women have overcome, and about the hidden codes and networks that exist, independent of gender. In addition, the students should be mentored not only to be successful engineers, but also to become entrepreneurs in the field.

A mentor can have several students, maybe up to four. The mentoring program includes receiving professional guidance, visiting local companies, thus becoming acquainted with the actual work performed by an engineer. The possibility of getting a job in one of these companies will be an inspiration to the students. The program will outline and recommend certain activities, and arrange some gatherings for all mentors and mentees. The mentor and mentee themselves decide how many times they will meet during a semester, and the nature of those meetings.

Recruiting the mentors is not difficult, all the women who have been asked so far have answered in the affirmative. They recognize the problem, and wish to contribute with their knowledge and experience in order to aid the young students in their first meeting with the professional field of engineering. In addition, they wish for more female colleagues in their work place, and hope that establishing close contact with the college and the students will help to recruit more female engineers. Therefore, the aim of the project will be two-fold: To retain the female students and help them to succeed, and to recruit women into the engineering industry.

SUMMARY

Today, the total representation of female students at the Faculty of Engineering is 18 percent. The official policy of the College is to recruit more women to the various study programmes. The women’s group and the mentor program are part of this recruitment strategy. The number of female students has been reduced somewhat during the last year, like in previous years, and it is hard to determine if the network group has had an impact on the numbers of female students. More research and data gathering is necessary in order to document the results of this work.

The mentor program will be launched in August 2006. One goal of the program is that in 2006/2007, all female first year students will have their own mentor. Another goal is to actively recruit female students, and to reach a minimum of 25 per cent enrolled female students by 2008.

REFERENCES


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The Athena project http://www.athenaproject.org.uk/

The need for facilitating mentorships for women in their professional organizations is evident (Bolton 1980; Clark and Corcoran 1986; Finkelstein 1984; Kram and Isabella 1985; Levinson 1978; Noe 1988; Speizer 1981). The only observed difference in mentoring experiences for men and women involved the psychosocial functions. Women were more likely to report that their mentors conveyed empathy for the concerns and feelings discussed with them than were men. Also the term "tokenism" is used to describe accomplished women or minority-group members who, once selected into a commonly white, male inner circle, become labeled as the "token" representative for their group.